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Towards an improved implementation of fire emission heights in earth system models

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Vegetation fires either set by humans or ignited naturally by lightning represent a complex interaction between the biosphere and the atmosphere. Aerosols and trace gases emitted by fires are known to impact a wide range of atmospheric processes including atmospheric chemistry, radiative transfer and microphysical cloud processes. As the climate impact of these atmospheric processes crucially depends on the lifetime of the emissions as well as on the height where the interactions take place, fire emission heights represent a key parameter of the overall fire climate impact. Earth system models do not account for variable injection heights depending on individual fire intensities and ambient meteorological conditions.

In this study we evaluate the widely used, region–specific plume height classification scheme suggested by Dentener et al., 2006, by comparing proposed plume heights to the MISR Plume Height Project (MPHP) data set. The analysis of about 7300 smoke plumes questions the appropriateness of a solely region–dependent model implementation of smoke injection heights. In the tropics and the temperate extra–tropics, the classification provides reasonable mean top injection heights, but neglects a significant fraction of deep injections. Plume height differences between boreal North American and Eurasian plumes were found to be insignificant in the MPHP data set. Injection heights in boreal regions are overestimated by the region-dependent classification scheme for more than 95% of all plumes.

As the MPHP data set also serves as an observational evaluation data set for modeled smoke plume heights, the global representativeness of the current MPHP data set is tested regarding vegetation and climate zones coverage, plume age variations and the inclusion of pyrocumulus events. Overall the MPHP data set constitutes a widely representative data set for plume model evaluation, but the fire radiative power (FRP) turns out to be the most uncertain and challenging parameter.

In order to improve the current implementation of the emission injection heights in the earth system model of the Max Planck Institute for Meteorology (MPI-ESM), we implement the semi-empirical, one dimensional plume model introduced by Sofiev et al., 2012. In a first step, we limit our investigations to the basic implementation of the Sofiev model and use atmospheric stability parameters simulated by the global circulation model ECHAM6 (resolution T63, nudged with ECMWF reanalysis data) and prescribed FRP from the MPHP data set to simulate fire injection heights. Here, we present first results of the simulated injection heights. Future, fully coupled simulations of the fire model JSBACH–SPITFIRE, the 1-D plume model and ECHAM6 will enable to study climate–related plume height variations and thus help to enhance our understanding of the fire climate impact.